

which lead to the calculation of the efficiency of refrigerating engines.

Starting with the conception of a refrigerating engine as a heat pump which requires the expenditure of mechanical energy to bring heat from a lower to a higher level of temperature working on a reversed Carnot's cycle, the significance of indicator and entropy diagrams is explained in non-mathematical language. The thermodynamical details are worked out more completely in various appendices. These include discussions of entropy (ϕ) diagrams, with either temperature or thermodynamic potential (i) as the other coordinate. A reproduction on a large scale of Dr. R. Mollier's ϕ - i diagram for carbon dioxide is given at the end of the book, and its usefulness in tracing the exact behaviour of an engine using this as working substance is shown. There are also tables of the properties of ammonia, sulphur dioxide, carbon dioxide, and water vapour which would be necessary in such calculations. All these data are given in C.G.S. units, and it is to be regretted that these have not been used throughout the book so as to make it more uniform, and also because there is a strong opinion now that either C.G.S. or some derived units founded on them would be used internationally in applied thermodynamics with the same advantage as they have been in applied electricity.

Absorption and air-compression machines are now only employed in special cases, but they are interesting, and are considered in the second and third chapters.

At the present time, nearly all new installations use the vapour-compression system to which the fourth chapter is devoted. The substances which are used are water vapour, which is clearly only applicable in very special cases, carbon dioxide, sulphur dioxide, ammonia, and methyl chloride. Each of these has special applications, determined by size or danger of explosion, or the unwholesome nature of the gas, in addition to their efficiencies as working substances. It is shown that the theoretical efficiencies increase in the order given with the exception of the last, which is only just mentioned, although it is employed in well-known cascade installations, and is coming into use largely as a convenient substance for small portable machines on rail-road cars and similar places. This chapter, in connection with the following sections devoted to the testing of refrigerating machines, especially by the Munich method, should be of considerable use to students and other workers in this field. Short accounts follow of the principal applications of moderate cold in industries such as brewing and others depending on fermentation processes, also in ice-making, and in the preservation and transport of food and other perishable articles. A section is devoted to the cooling of magazines in ships of war, about which the author writes with special authority.

The remainder of the book discusses the production and application of very low temperatures, such as those obtained by liquid air, liquid hydrogen, and now quite recently by liquid helium. There are three principal methods of reaching these low temperatures, which are all described: the cascade of Cailletet and Pictet, the expansion method of Siemens and others,

and the combination of the cooling due to throttling and the regenerative principle by Linde. The main industrial application is for the production of oxygen from liquid air, which is obtained by the Linde process or by the modification of this introduced by Claude, in which the Siemens principle is combined with it. There are considered in detail, and it is shown how the rectification is carried out so that nearly pure nitrogen, as well as nearly pure oxygen, is obtained by the same process. Dewar's work on hydrogen follows, with a *résumé* of its properties and a mention of those of liquid helium.

The book is well illustrated with diagrams and drawings, and has a good index. F. H.

OUR BOOK SHELF.

Principles and Methods of Physical Education and Hygiene. By W. P. Welpton. Pp. xix+401. (Cambridge: University Tutorial Press, Ltd., 1908.) Price 4s. 6d.

THIS book is addressed to the teachers of elementary schools, and to such of them as enjoy the study of physiology much pleasure will be derived from the perusal of every chapter. The author, we see, is master of method in the University of Leeds; he describes methods as well as theory of cleanliness, ventilation, care of the eye, and such "first aid" as is likely to be called for. More theory than method, however, is set down to advance the practising of the physical exercise part of physical education. We have no idea how the author would arrange to get the best use out of the school playground; how he would attain some organisation of games among scholars without encroaching upon the teacher's time.

"Glycogen" is referred to seven times in the index, but one can find no list of games or activities that suit the different periods of school life, such as would be helpful to the organiser of physical education; accordingly one regrets that theory dominates this work. We are apt to forget that our professional trainers of athletes have been very successful in their way, and with them athletics called the trainers into being; a development of play is the first step towards bettering physical education.

Everyone interested either in games or physical education in its fuller aspect will be delighted with the chapter on the history of physical education, contributed by Prof. J. Welton, with quotations such as that from Lucian on the Athenian boy. "When he has laboured diligently at intellectual studies and his mind is sated with the benefits of the school curriculum, he exercises his body in liberal pursuits, riding or hurling the javelin or spear. Then the wrestling school with its sleek oiled pupils labours under the midday sun, and sweats in the regular athletic contests. Then a bath, not too prolonged; then a meal, not too large, in view of afternoon school. For the schoolmasters are waiting for him again, and the books which openly or by allegory teach him who was a great hero, who was a lover of justice and purity. With the contemplation of such virtues he waters the garden of his young soul. When evening sets a limit to his work, he pays the necessary tribute to his stomach and retires to rest to sleep sweetly after his busy day." Education in this breadth and spirit, lost in the dark ages—for the exercises of chivalry do not represent it—was revived in Italy at the Renaissance, and the first English exponents of this revival—Mulcaster, 1581, and Sir Thos. Elyot, 1531—had their influence dominated by the Puritanism

of those and later times. Perhaps the latter spirit is still effective, as cricket is apparently never played on Sunday.

The neglect of physical education up to the time of Rousseau is sketched by Prof. Welton, and its advance since then in secondary schools. He tells us with regard to elementary schools that the conception of education that guided the Education Act of 1870 was essentially the scholastic tradition, that education and instruction are synonymous, and he affirms the most crying need in English education of to-day to be adequate provision for physical training. H. R. B.

Bathy-orographical Map of the British Isles. Natural Scale 1: 875,300, or 14 miles to an inch. *Bathy-orographical Map of South America.* Natural Scale 1: 6,150,000, or 97 miles to an inch. Constructed and engraved by W. and A. K. Johnston, Ltd. Prices not stated.

Handbook to accompany the Map of the British Isles. Pp. 32. Price 6d. net.

No more convincing indication could be found of the improvement which has taken place in recent years in the methods of geographical instruction in schools than the enterprise shown by publishers in the production of good orographical maps, both in atlases and on a large scale for class-teaching purposes. The present wall-maps are good examples of the excellent aids which are available to assist teachers in demonstrating the fundamental importance of the distribution of the highlands and lowlands of the areas being studied. In the map of the British Isles six shades of brown are employed to show graphically the course of important contours on the land, and two shades of blue indicate the 20- and 50-fathom lines in the surrounding seas. In the case of South America the varying heights of the land above sea level are depicted by five shades of brown and two of green, while the 100-, 1000-, and 2000-fathom lines are shown on the oceans. Care has been taken to avoid crowding, and the maps are models of clearness.

The "Handbook" should prove a great help to those teachers of geography who have had little experience in teaching their subject by modern practical methods.

Invariants of Quadratic Differential Forms. By J. E. Wright. Pp. vi+90. Cambridge Tracts in Mathematics and Mathematical Physics, No. 9. (Cambridge: University Press, 1908.) Price 2s. 6d. net.

THIS number of the Cambridge Tracts deals with a clear and definite problem, the simplest case of which may be stated as follows. Let a, b, c be given functions of the independent variables, x, y , and let

$$ad^2x^2 + bdx dy + cdy^2$$

become

$$a'd'^2\xi^2 + b'\gamma d'\xi d\eta + d'\eta^2$$

by a change of variables from (x, y) to (ξ, η) ; what functions of a, b, c and their differential coefficients transform into the same functions of a', b', c' and their differential coefficients? The importance of this inquiry begins to appear in Gauss's celebrated memoir on the deformation of surfaces; and a very large part of what is called the differential geometry of surfaces is, from another point of view, the invariant theory of a quadratic differential form in two variables. In the general theory there are n variables, and the first great step in this direction was taken by Riemann; references to his principal successors are given by Prof. Wright (pp. 5-8). The methods explained in the tract are those of Christoffel, Lie, and Maschke;

the last, which is symbolical, and quite recent, is only very briefly summarised, but enough is done to show its interesting character. Another special calculus applied to the subject is that of Levi-Civita and Ricci (pp. 20-8); and other manipulative devices may doubtless be discovered. So far as one can see at present, the essential elements of the theory are the Riemann-Christoffel four-figure symbols; while the broadest aspect of it is presented by Lie.

Pp. 51-90 give various geometrical and dynamical applications, concluding with the representation of one manifold on another with correspondence of geodesics. Besides being a useful guide to the analytical theory, this tract will be of service to readers of Darboux's and Bianchi's works on the theory of surfaces.

G. B. M.

A Course of Plane Geometry for Advanced Students. Part I. By C. V. Durell. Pp. xi+219. (London: Macmillan and Co., Ltd., 1909.) Price 5s. net.

THIS is a really capital book for students of what may be called scholarship standard. It contains, among other things, sections on similarity, transversals, vector geometry, inversion, and coaxial circles. As examples of the author's choice of elegant methods, and his clearness of exposition, may be taken the proof (due to Mr. Hillyer) that the centres of the diagonals of a complete quadrilateral are collinear (p. 118), and the proof of Feuerbach's theorem by inversion (p. 149). In the latter example, as in many others, teachers will notice the excellence of the diagrams, which give, without confusion, all that is required and no more. There is a practically inexhaustible stock of examples, with a very wide range of difficulty. Mr. Durell is a master at Winchester College, and those who remember the late Mr. Richardson's success in making his boys like and learn geometry will be glad to see that there is no risk of the subject being neglected now that he is gone.

The Contents of the Fifth and Sixth Books of Euclid. By M. J. M. Hill. Second edition. Pp. xx+167. (Cambridge: University Press, 1908.) Price 6s. net.

THIS is a new work rather than a new edition. Prof. Hill has now completely abandoned Euclid's treatment of proportion as given in his fifth and sixth books, and replaced it by an arithmetical theory. Two commensurable quantities, pA, qA , are defined as having the ratio p/q . Equal ratios are defined as those between which no rational fraction lies. The theory is now made rigorous by means of Dedekind's treatment of irrational numbers, the Cantor-Dedekind axiom, and the axiom of Archimedes. It is a foolish man that never changes his mind; and Prof. Hill's deliberate change of method after eight more years of teaching is a fact to which special attention should be directed.

The Elementary Dynamics of Solids and Fluids. By Prof. W. Peddie. With Sectional and General Examples by J. D. Fulton. Pp. xii+188. (Edinburgh and London: Oliver and Boyd, 1909.) Price 2s. 6d.

THIS little book is intended for use by junior students in university classes, and for boys in the higher forms of secondary schools. The treatment is very elementary, and fluids are disposed of in the concluding three of the thirteen chapters. The wisdom of printing answers immediately after the exercises throughout the book may be doubted. As an introduction to dynamics, the book should prove useful.